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GERAGHTY & MILLER, INC.

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REVISED WORK PLAN

FOLLOW-ON INVESTIGATION OF GROUND-WATER CONDITIONS AT THE HONEYWELL, INC. SIGNAL ANALYSIS CENTER ANNAPOLIS, MARYLAND

PREPARED FOR:

HONEYWELL, INC.
SIGNAL ANALYSIS CENTER
ANNAPOLIS, MARYLAND

AUGUST, 1988

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ORIGINAL (Red)

TABLE OF CONTENTS

ORIGINAL (Red)

INTRODUCTION

Geraghty & Miller, Inc. (G&M) completed a comprehensive investigation of ground water, soils and wastewater disposal at the Honeywell Signal Analysis Center, Annapolis, Maryland in June 1988. Several follow-on activities were proposed in order to accurately assess the feasibility of certain remedial measures for recovering ground water with volatile organic compounds (VOCs). This work plan describes in detail these follow-on activities.

Five follow-on activities proposed in the June 1988 report are listed below.

- Testing of the Aquia and Brightseat Formations for transmissivity, hydraulic conductivity and storage coefficient.
- Surveying the road-side ditch south of MD Rt. 450.
- Identification of flow paths north of MD Rt. 450 leading to the tributary to Broad Creek.
- Continued development of GM-11.

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(Red)

- Another full round of sampling of the monitoring-well network and selected stream/ditch locations.

Two additional activities were identified during the July 22, 1988 meeting with State and City officials. One of the activities, the installation of another deep monitoring well adjacent to GM-12, was added at the request of the City of Annapolis. The second activity added involved a modeling study to estimate changes in ground-water flow as a result of a potential recovery system.

The objectives of this follow-on investigatory work are:

- Determine hydraulic properties of the uppermost aquifer that are important to the design of a ground-water recovery system.

- Surveying elevations and determining soil conditions in the roadside ditch south of MD Rt. 450 for use in recovery system design.

- Determine in more detail the extent of VOC containing ground water in the vicinity of MD Rt. 450 and adjoining surface waters (includes identification of flow paths to the tributary).

ORIGINAL (Red)

- Study via computer modeling potential capture zone geometries for various ground-water recovery system configurations (including passive and active recovery approaches).

After completion of these follow-on investigations, an engineering feasibility/conceptual design study can then be undertaken.

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TECHNICAL APPROACH

The results of the G&M investigation indicate that ground-waters containing volatile organic compounds (VOCs) are found in the the uppermost aquifer. These waters were found to flow from the potential source area near the Signal Analysis Center to a road-side ditch along the south side of MD Rt. 450. This investigation involves the installation of monitor wells and aquifer testing, such that hydraulic parameters can be evaluated. Also, sampling of mini-piezometers and monitor wells in and near the stream will provide characterization of seasonal changes in ground-water flow patterns.

The tasks required to implement this investigation are listed below:

Task 1 - Drilling Program and Monitor Wells

Task 2 - Aquifer Testing

Task 3 - Identification of Flow Paths North of MD Rt. 450

- Task 3.1 -- Surface-Water Sampling
- Task 3.2 -- Mini-Piezometers
- Task 3.3 -- Water-Level Measurements

Task 4 - Water Quality Sampling

Task 5 - Roadside Ditch Characterization

Task 6 - Continued Development of GM-11

Task 7 - Ground-Water Flow Modeling Study

Task 8 - Reporting

ORIGINAL (Red)

The time frame for completion of all tasks and submittal of a draft report to the State of Maryland is approximately three months from date of authorization. This is assuming that there are no time delays as a result of permitting for access to drilling locations, prolonged periods of inclement weather, major equipment breakdowns, or any delay not controllable by G&M or Honeywell. Approximately two months time will be needed to carry out field program elements.

Each of these tasks is further detailed in the following pages. A revised Health and Safety Plan has been included as Appendix A.

<u>Task 1 -- Drilling Program and Monitor Wells</u>

G&M will inspect the installation of six monitor wells (GMP-22, GMP-23, GM-24, GM-25, GM-26 and GMP-27) at locations shown on Figure 1. The work will be performed by a qualified drilling subcontractor and will meet all State of Maryland standards and specifications.

Monitor-well construction procedures will be as described in the previous work plan for the recently completed study (see June 1988 report). One deep borehole (GM-25) will be drilled using the mud-rotary method to the top of and slightly into the confining unit overlying and separating the uppermost aquifer (i.e., Aquia and Brightseat

ORIGINAL (Red)

Formations) from the Magothy Aquifer (approximate depth of 70-80 feet). Soil Samples will be collected at 5-foot intervals. A Shelby tube sample will be taken from the confining unit and tested for porosity and permeability. The borehole will be geophysically logged prior to well construction for detailed lithologic information over the length of the boring. The portion of the borehole drilled into the confining unit will be appropriately sealed with a plug of bentonite pellets after logging. The borehole will then be converted to a 4-inch-diameter monitor well screened immediately above the confining unit. This deep well shall consist of 4-inch-diameter threaded PVC casing and 10-slot PVC screen.

A second shallow (approximately 20-30 feet) borehole (GM-26) will be drilled using a wet-rotary technique with an artificial mud (e.g., "E-Z mud") instead of bentonite clay mud. This borehole will be drilled to the top of the Brightseat Formation. Soil samples will be collected at five foot intervals. This borehole will be converted to a 4-inch-diameter "aquifer test well", using 4-inch-diameter threaded PVC casing and 10 feet of 4-inch diameter continuous 10-slot PVC screen.

A third shallow boring (GMP-27) will be drilled in close proximity to GM-26. The borehole will be drilled using standard hollow-stem augers. Soil samples will be taken

ORIGINAL (Red)

continuously with a split-spoon. This borehole will be converted to a two inch-diameter threaded PVC observation well screened across the same interval as GM-26 using 10-slot screen.

A fourth shallow boring (GM-24) will be drilled using the mud rotary method. This borehole will extend 10-15' below the water table. Soil samples will be collected at five foot intervals. The borehole will be converted to a 4-inch-diameter well and screened across the water table. If a drill rig site is not accessible, a hand auger boring and 2" monitor well (GMP series) will be installed instead. See the June 1988 report (section 3.5 Task 5) for construction details.

Two shallow borings (B-1 & B-2) will be drilled to the top of the Brightseat Formation using standard hollow stem augers and sampled continuously for detailed lithologic information. Immediately after drilling each, the borings will be abandoned with a bentonite grout to the surface.

The remaining two borings (GMP-22 and GMP-23) will be installed along the hillside south of MD Rt. 450 using a hand-auger and converted to 2-inch diameter PVC monitor wells (GMP series). See the June 1988 report (Section 3.5 Task 5) for construction details.

ORIGINAL (Red)

All drilling tools will be thoroughly steam cleaned prior to initiation and between boreholes. A soil sample will also be collected from the interval to be screened by each well, and will subsequently be analyzed for parameters in Suites A and C as listed in the work plan in the June 1988 report.

For boreholes to be drilled with the rotary technique, soil samples will be collected at 5-foot intervals with a split-spoon sampler. Hollow stem auger borings will be continuously sampled for detailed lithologic information, and archived. The split spoon will be thoroughly cleaned between samples. Soil samples will be field described for important physical features (i.e., particles size distribution, and color) and placed in sealed receptacles. The head spaces of the receptacles containing archived samples will be screened in the field for volatilized organics with a Photovac TIP. Soils containing VOC's will be appropriately containerized and taken to an approved treatment facility.

All well heads will be completed with locking cap and cover, and a concrete pad. Well development procedures are detailed in Appendix B of the June 1988 report. All well casing and ground-surface elevations will be surveyed and used to provide water-level elevation information.

ORIGINAL (Red)

Task 2 -- Aquifer Testing

G&M will perform a constant rate aquifer test in GM-26 to determine hydraulic properties of the uppermost (water-table) aquifer. GMP-27 will be used as the observation well. Information gained from the test will include estimates of aquifer transmissivity, hydraulic conductivity, and storage coefficient. A short pre-test will be performed to determine the most appropriate pumping rate.

In the event that GM-26 cannot be installed, the aquifer test will be conducted in GM-10. GM-8 and GM-9 will then be used as observation wells.

A submersible or centrifugal pump will be used for the aquifer test. Flow will be monitored to maintain a constant rate and test duration will be approximately 24 hours depending on aquifer behavior as the test progresses. All discharge waters containing VOC's will be containerized in plastic or metal drums, transferred to a bulk holding tank and shipped to an approved hazardous wastewater treatment facility. Appropriate methods will be used to analyze drawdown and recovery data.

ORIGINAL (Red)

Task 3 -- Identification of Flow Paths North of MD Rt. 450

G&M will perform a stream study to determine to what areal extent ground waters are discharging to the stream north of MD Rt. 450. The stream study will be conducted in three parts as follows:

Task 3.1. Surface-Water Sampling

The stream sampling locations and ditch sampling locations used in the June 1988 report will be resampled to obtain results during low flow periods. Specific conductance, pH, and temperature will be measured in the field. Samples will be analyzed with a portable gas chromatograph (with laboratory confirmation of selected samples) for identifiable constituents. Two additional sampling locations will be added, DC-1 and S-10 as shown on Figure 1.

Task 3.2. Mini-Piezometers and Stream Gauging

At five locations, mini-piezometer strings will be installed as shown on Figure 1. At these locations, head differences between the ground water and the stream surface will be measured and the ground water will be sampled. All ground-water samples will be analyzed with a portable gas chromatograph (with laboratory confirmation of selected samples) for identifiable constituents. The installation and sampling procedures for mini-piezometers are outlined in Appendix B of the June 1988 report.

The flow in both the roadside ditch and the tributary stream will be gauged at selected points.

Task 3.3. Water-Level Measurements

A complete round of water-level measurements will be taken in all wells across the site. With this information, a ground-water flow net and water level contour map will be generated.

Task 4 -- Water Quality Sampling

G&M will measure water levels and resample all of the previously installed monitor wells and all new monitor wells prior to the Aquifer test. All samples will be analyzed for Suites A and C parameters described in the June 1988 report plus total suspended solids. Samples will be collected using the same procedures outlined in Appendix B of the June 1988 report. Samples from wells screened in the Aquia Formation will be replicated into filtered and unfiltered samples. Filtered samples will only be analyzed for Suite C metals, pH, dissolved solids and total suspended solids. During the

ORIGINAL (Red)

course of evacuating well GM-10, water levels will be monitored in the three cluster wells (GM-8, GM-9, GM-10). If possible, aquifer characteristics and properties will be estimated with the data obtained.

Task 5. Roadside Ditch Characterization

G&M will contract a registered surveyor to survey the roadside ditch south of MD Rt. 450. This will include transects across the entire ditch at 100 foot intervals. A one-foot contour topographic map of the ditch will then be generated.

G&M will also inspect three hollow-stem auger borings (B-1, B-2, and GMP-27) in the vicinity of the roadside ditch south of MD Rt. 450 (See Figure 1 for locations and Task 1 for description of borings). These borings will provide preliminary geotechnical information about the soils beneath the roadside ditch and depth to the top of the Brightseat Formation. This information may be of importance in evaluating the feasibility of a drain to collect ground water containing VOCs.

Task 6. Continued Development of GM-11

Development of GM-11 will be continued. Well development will terminate when the water quality stabilizes

ORIGINAL (Red)

with respect to VOC's and turbidity. This development will ensure that adequate recharge into the well occurs, and that representative ground-water samples are collected. Development may be accomplished using methods described in Appendix B of the June 1988 report except that water will not be added to the well. Pumped and bailed water will be containerized.

Task 7 -- Ground-Water Flow Modeling Study

G&M will construct a detailed numerical model designed to investigate ground-water flow conditions at the Honeywell site. Four specific modeling subtasks will be carried out as follows:

- Develop a conceptual model of the ground-water flow system at the Honeywell site.

- Calibrate a steady-state numerical flow model to site ground-water flow conditions using all available data and perform sensitivity analysis.

- Perform particle-tracking analysis to predict present ground-water flow directions under average conditions.

ORIGINAL (Red)

- Perform a preliminary assessment of remedial alternatives through capture zone analysis.

This numerical model for the Honeywell site will investigate the water-table aquifer in the Aquia and Brightseat formations. In the model, this aquifer will be discretized into multiple (two or three) layers to incorporate any three-dimensional aspects of the flow system. For purposes of this modeling study, the Monmouth/Matawan aquitard unit will be treated as an impermeable no-flow boundary at the base of the model. The areal domain of the flow model will be designed to include the significant features of the ground-water flow system that control flow at the Honeywell site. A steady-state calibration will be performed to represent average conditions at the site.

In modeling subtask no. 1, a conceptual model of ground-water flow conditions will be developed for the Honeywell site. A conceptual model includes the essential physical features of a flow system necessary for mathematical treatment by a numerical model. Hydraulic properties, boundary conditions, and source/sink elements are identified in a conceptual model. For example, at the Honeywell site, hydraulic properties such as aquifer hydraulic conductivity and storage coefficient, boundary conditions such as stream elevations and no-flow boundaries, and sources and sinks such as well pumping rates and precipitation recharge will be estimated in the development of the conceptual model. Estimated recharge from active dry wells will also be included in the model. In general, site-specific information for the identification of these model parameters will be available from G&M investigations at the Honeywell site. In essence, the conceptual model will provide a framework for the numerical model input data set.

In modeling subtask no. 2, the input data set for numerical model will be constructed incorporating the key physical elements defined in the conceptual model. Calibration of the model will begin after the construction of the input data set is complete. Model calibration refers to the process of systematically adjusting hydraulic parameters in a model until hydraulic heads predicted by the model match measurements of hydraulic head obtained in the field. Examples of hydraulic parameters adjusted during calibration include hydraulic conductivity, storage coefficient, and precipitation recharge.

In general, adjustment (calibration) of hydraulic parameters in a numerical model are constrained by available field estimates of the parameters. Aquifer test(s) conducted by G&M at the Honeywell site (Task 2) will provide site-specific field data for the calibration of the model. Additional data for model parameters will be taken from the literature.

The calibrated numerical model for the Honeywell site will simulate average, steady-state conditions. Calibration targets (field measurements of hydraulic head used to check the calculations of the numerical model) will be selected from available water-level measurements in observation wells at the site to represent these conditions.

A discrete sensitivity analysis will be performed after the model calibration is completed. By varying individual parameters in the model independently, the sensitivity of the final solution to each parameter will be quantified.

In modeling subtask no. 3, particle-tracking analyses will be performed to assess ground-water flow directions and travel times under current flow conditions. Particle-tracking is an analytical technique which predicts the migration of a dissolved chemical species in ground-water in the absence of dispersion, adsorption, and decay. This method of analyzing solute transport traces the "center-of-mass" of a contaminant plume. Futhermore, it provides a means of delineating capture zones for wells and drains by identifying limiting flowlines. Ground-water velocities required by the particle-tracking method will be generated from the calibrated ground-water flow model.

In modeling subtask no. 4, additional particle-tracking analyses will be performed to assess the impact of various

ORIGINAL (Red)

remedial alternatives on ground-water flow. Three specific remedial alternatives will be investigated as follows:

(1) drain without ground-water recirculation,

(2) drain with ground-water recirculation, and

(3) drain with mid-plume wells.

Ground-water recirculation refers to the reinjection of treated ground-water pumped from the drain at a location upgradient of the Honeywell site. For each scenario, particle-tracking will be performed to investigate the relative effectiveness of each remedial methodology in terms of its capture zone.

A publicly available, well-documented, and widely applied ground-water flow code named MODFLOW (McDonald and Harbaugh, 1984) will be used for this model application. This code, written by and available thorough the U.S. Geological Survey, simulates transient or steady-state, three-dimensional ground-water flow in multi-aquifer systems with options for a phreatic water surface, wells, rivers, drains, precipitation, and evapotranspiration. MODFLOW uses the method of finite differences to solve the partial differential equations for ground-water flow.

Particle tracking will be performed with the publicly available code STLINE (Reeves et al., 1986). Ground-water flow velocities computed from the MODFLOW code will be used to evaluate ground-water flow directions in three-dimensions with STLINE.

Task 8 -- Reporting

G&M will prepare a report to present the results of all tasks in this investigation. The report will include borehole logs, well construction diagrams, a revised cross section and the results of the aquifer test and water quality sampling. Also to be included are a water level map and detailed topographic map of the MD Rt. 450 corridor adjacent to the Honeywell property. One chapter of the report will focus on results of the modeling study. Another chapter will discuss the flow routes north of MD Rt. 450. Principle findings with respect to hydrogeologic behavior, ground water recovery, discharge system performance, and extent of VOC containing ground water will be reported.

ORIGINAL (Red)

REFERENCES

McDonald, M. G. and A. W. Harbaugh, 1984. A Modular Three-Dimensional Finite-Difference Groundwater Flow Model, Open File Report 83-875, U. S. Geological Survey, Reston, VA.

Reeves, M., D. S. Ward, N. D. Johns, and R. M. Cranwell, 1986. Theory and Implementation for SWIFT II, the Sandia Waste-Isolation Flow and Transport model for Fractured Media, release 4.84, NUREG/CR-3328, SAND83-1159, Sandia National Laboratories, Albuquerque, NM.